

Campbell. (F. R.)

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OF
INFANTILE DIARRHCEAL DISEASES,

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INFANTILE DIARRHŒAL DISEASES.*

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Jules Simon has said that we add more to the strength and prosperity of a nation by the prevention of disease and death than by the conquest of foreign territory. It is a low death-rate rather than a high birth-rate which produces a rapid increase in population. It requires France 192 years to double her population. In Prussia this is accomplished in 54 years; in England in 52 years, while Buffalo by the same method of computation will double her population from natural growth every 69 years.

Preventive medicine has made remarkable progress during the past century. Sickness has been greatly reduced, death has been robbed of a host of victims, and the average duration of life has been increased at least twenty per cent. Jenner by his immortal discovery has saved thousands from death, blindness and disfiguration. Ferran, Freire and Pasteur promise us immunity from Asiatic cholera, yellow fever and rabies. We may even hope to find a clue to the causes and cure of that dread

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malady, consumption. It is to a small field in the department of preventive medicine that I wish to invite your attention this evening, promising you no new discoveries, but simply applying, as far as possible, old facts to a new locality—our own city.

My subject is "The Causes and Prevention of the Diarrhœal Disease of Infants," and it is my desire to point out the local sources of these affections and trace their relation to the mortality of infants in general.

No city in the United States has more accurate vital statistics than Buffalo. Our death reports are almost absolutely correct, while the birth returns are less defective than in most other American cities. We may therefore safely employ these statistics as the basis of some of our investigations.

During the past six years, from 1881 to 1886 inclusive, 32,769 births have been reported to the Registrar of Vital Statistics, and during the same period 10,714 deaths have occurred among those under five years of age, showing that about one-third of all children born die before reaching the sixth year of life. Moreover, 6,684, or 20 per cent. of all born, died during the first year of life; 2,041, or 12.17 per cent. of the children one year old, died in the second year; 946, or 6.2-10 per cent. of the children two years old, died in the third year; 550, or 4 per cent. of the children three years old, died in the fourth year, and 479, or 3½ per cent. of the children in the fifth year, died annually.

If we compare this death-rate with that of European cities, we will be forced to the conclusion that Buffalo is a remarkably healthy place for babies, if not the healthiest city of its size, in the world. We have only to compare our death-rate for children under one year of age, 20 per cent., with the rates given by Ecklund for several cities of Europe in 1872 to observe the remarkable difference:

City.	Deaths per 100 under 1 Year.	City.	Deaths per 100 under 1 Year.
Paris,	30.8	Vienna,	42.8
St. Petersburg,	32.5	London,	43.5
Milan,	32.5	Dresden,	46.3
Prague,	32.8	Venice,	46.5

City.	Deaths per 100 under 1 Year.	City.	Deaths per 100 under 1 Year
Turin, .	32.9	Hamburg, .	48.4
Marseilles, .	35.3	Rotterdam, .	53.6
Naples, . .	36.4	Munich, . . .	55.5
Rome, . . .	40.4	Stuttgart, . .	56.4
Moscow, . .	40.4	Berlin, . . .	58.1

The average infant mortality for all Europe is 25.4 per cent. In the large cities of the United States with the exception of Buffalo—that is, in Boston, New York, Philadelphia, Chicago and St. Louis—the infant mortality is said to be fifty per cent., which is manifestly too great, as the birth returns in all these places are very defective. In the various departments of France where vital statistics are accurately recorded, it has been found that the mortality of infants during the first year of life varies from five per cent. in the Department du Rhone to eighty-five per cent. in the Department du Loire Inferior, the average for all France being according to Monot seventeen and a-half per cent. France has the lowest infant mortality on the Continent, a fact which is in part due to the low birth-rate. Great pains are taken with the few children born, and as a consequence the mortality is low; the Germans have a birth-rate nearly double that of the French, but the mortality is enormously increased. A sarcastic French writer has said that “Germans like hogs are very prolific animals, and their offspring are likewise liable to die young.”

French sanitarians are in the habit of considering seventeen and a-half per cent. as the normal rate of infant mortality, but Monot maintains that five per cent. is much nearer what the normal should be, as the death-rate is found to be as low as this where the best sanitary conditions are observed. In other words he claims that the French people through carelessness and ignorance destroy one-eighth of their infants during the first year of life, and we of Buffalo lose one-sixth of our infants for the same reasons.

With the hot sultry days of summer comes a slaughter of the innocents in all northern American cities far greater than

that which Herod ordered, and this excessive mortality is due largely to diarrhœal affections, a class of diseases regarded as preventible by the great majority of sanitarians. The following table will show the number of deaths from diarrhœal diseases in Buffalo occurring among those under five years of age during the past six years, and the percentage of all deaths for the same time due to these causes :

Year.	Deaths from Diarrhœal Disease under 1 year.	From 1 to 2 years.	From 2 to 3 years.	From 3 to 4 years.	From 4 to 5 years.	Total from Diarrhœal Diseases under 5 years.	Per cent. of Deaths all under 5 years from Diarrhœa.	Total Deaths under 5 years from all causes.		
1881..	291	149	38	11	11	500	27	1,851		
1882..	311	76	9	2	6	407	20½	1,973		
1883..	308	58	9	2	2	379	26	1,475		
1884..	336	111	25	12	7	491	26	1,890		
1885..	344	71	12	5	2	434	25	1,697		
1886..	335	75	11	3	1	425	23½	1,828		
Total.	1,925	540	140	35	29	2,633	24½	10,714	45.6 of	all deaths
Per ct.	73	20½	3½	1⅓	1⅙	100				

This table shows that there have been 2,633 deaths from diarrhœal diseases among young children in this city during the past six years, and that nearly one-fourth (24½ per cent.) of all deaths among children are due to these maladies.

To discuss the etiology of infantile diarrhœal diseases in our climate is to discuss the causes of infant mortality in general. Whatever diminishes the strength and vigor of the system tends to produce intestinal disease in summer. There are a host of causes, some of which act in a very indirect manner; but no specific cause has yet been discovered. But for the sake of a classification we may divide the factors which we are about to consider into five classes: developmental, social, meteorological, sanitary and dietetic.

I. DEVELOPMENTAL CAUSES.

1. *Age*.—To speak of age and sex as causes of a disease is manifestly illogical, and yet these conditions have close relations

to the causation of many affections. In infancy there is the greatest activity of the assimilative functions; the child attains nearly half its mature weight and stature during the first three years of life. The younger the child the greater the activity of nutrition and the less the power to resist disease. There are certain peculiarities in the digestive organs of infants which deserve a passing mention. The glycogenic ferments are not found in the saliva and pancreatic fluids until the first teeth appear, pepsin is secreted in but small quantities by the gastric glands, and the liver does not properly convert the peptones, uric acid being formed and eliminated instead of urea. Prof. Owen has shown that in the early stages of human life the functions of many organs resemble those of the lower animals. Birds and reptiles excrete uric acid instead of urea normally, owing to certain peculiarities in their hepatic organs. In the infant, the syphilitic child and the gouty man the same peculiarity is observed, and a carefully restricted diet is required. During the first two months of life the sweat glands possess but little if any functional activity. By regulating cutaneous evaporation these organs preserve the normal temperature of the body, but since their functions are so defective in infancy, sudden changes in the temperature of the surrounding atmosphere will affect the normal heat of the blood. When fluids cannot be eliminated by the skin for the reduction of temperature, copious discharges from the bowels are excited, a phenomenon which is usually attended with a loss of bodily heat.

Of the 2,633 deaths from diarrhoeal diseases among children which have been reported during the past six years, 73 per cent. have been under 1 year of age, $20\frac{1}{2}$ per cent. between 1 and 2 years, 4 per cent. between 2 and 3 years, $1\frac{1}{2}$ per cent. between 3 and 4 years, and 1 per cent. between 4 and 5 years of age.

Furthermore, 29 per cent. of all deaths among children under 1 year of age in Buffalo are due to diarrhoeal diseases; $26\frac{1}{2}$ per cent. of those between 1 and 2 years of age, 10 per cent. of those between 2 and 3 years, $6\frac{1}{2}$ per cent. of those between 3 and 4 years, and $6\frac{1}{4}$ of those between 4 and 5 years of age are

due to the same causes, showing that not only does the mortality from these affections but also the relative proportion of all deaths attributable to them vary inversely with the age.

Dr. J. Lewis Smith observed that the mortality from diarrhoeal diseases among infants from 6 to 12 months of age was double that of children under six months of age. This increased mortality during the latter half of the first year is attributed by some writers to the occurrence of dentition at this time; but the comparative immunity observed during the first six months of life is largely due to the fact that more are nursed at the mother's breast, and it is not all demonstrated that they are less liable to intestinal diseases, other circumstances being equal.

2. *Sex.*—The male child grows more rapidly than the female. The metamorphosis of tissues being greater, the liability to disease is proportionately increased and the power of resistance diminished. Nature has very kindly provided in part for this excess of male deaths by creating an excess of male births. But even with her best efforts a large number of our females must be doomed to perpetual maidenhood. During the past six years there have been 16,953 male births reported to 15,650 female births, showing that about 108 males are born to every 100 females. On the other hand, 118 males have died to every 100 females, and this great excess in the male death-rate is chiefly among children. Of the 2,633 deaths from diarrhoeal diseases among children in Buffalo, 1,412 have been males and 1,221 females, showing that 115½ male children die of these affections to every 100 females, an excess of male deaths nearly double the excess of male births. Bertillon has discovered that in Paris 121 males die under one year of age to 100 females, and that this proportion is about the same in other European cities. In other words, he claims that one fifth of all boys born die in the first year of life, while but one-sixth of the girls die during the same period. In Buenos Ayres where diarrhoeal diseases are quite as prevalent as in Buffalo, there is about the same difference in the death-rate of the sexes from these affections as in our city.

II. SOCIAL CAUSES.

Wealth.—Diarrhœal affections are pre-eminently diseases of the poor. Ignorance and filth are the usual accompaniments of poverty, and as a consequence all prophylactic measures are disregarded. Bouchut observed that the infant mortality in the eleventh, twelfth and seventeenth arrondissements of Paris, occupied principally by the poor, was more than double that of the children found in the sections occupied by those in comfortable circumstances. The same fact has been observed by Dr. J. L. Smith in New York. In some of the localities occupied by the poor, when acting as a sanitary inspector, he found cases of diarrhœa among the children in almost every house. In Buffalo the death-rate from diarrhœal diseases in the Fifth Ward, where a large number of Poles are found, is 4.7 per 1,000, nearly four times greater than that of the Ninth Ward, occupied by a wealthier class.

Joseph Lefort has studied the mortality of infants in industrial centres. In many of the factories of France and England, where women are employed, the children are left in crèches during the day, while the mothers are at work. In the crèche the children were dry-nursed, and as the women were in the habit of leaving their infants there on the ninth day after confinement, the mortality was frightful, in some places reaching eighty-three per cent. But a very simple remedy was discovered, which reduced this mortality in a remarkable manner. A fund was established by the proprietor of the Mulhouse Factory, to support the mothers at home until the children were seven weeks of age. In this manner the mortality was reduced to thirty per cent., and even less in some towns. We also have our crèche and working women, but the social relations of employers and the working classes are such in this country that any control of the sort just described would be impossible.

2. *Nationality.*—As a general rule, those nationalities having the highest birth-rate have the highest infant mortality and highest death-rate from diarrhœal affections. Among the Poles

and Germans diarrhoeal affections are common; they are moderately frequent among English, Irish and Italians, but rare among French and Scotch. It was at one time supposed that races coming from a cold climate to America were more liable to diarrhoeal affections than those who emigrate from hot countries, but statistics prove that this is not strictly true, for the Italians are not exempt from these diseases, nor are the Scotch from the north countries especially liable to them.

3. *Legitimacy*.—In France 9 per cent. of all the children born are illegitimate, while in Paris even 30 per cent. are born out of wedlock. Chauffard has made a careful study of the mortality of illegitimate children, and finds that it is about 100 per cent. greater than that of the legitimate. In Buffalo not 2 per cent. of the children are born out of wedlock, but the mortality among these is immense, as the records of lying-in asylums and "baby farms" would show. It is customary in this country to place these unfortunate babies with some woman who agrees to care for them for two or three dollars per week. For a hundred dollars many will stipulate to provide for the infant permanently, but in the great majority of cases the babies die of marasmus or enteritis before many months have elapsed. In France a bureau of wet nurses is provided by the public to care for these children. They are generally taken outside of the cities, but as each nurse cares for two or three babies, you may imagine that the wet-nursing is of a very defective character. Nevertheless, the mortality is much less than in our foundling homes where dry-nursing is the rule.

III. METEOROLOGICAL CAUSES.

The diarrhoeal diseases of children in our latitude are confined almost entirely to the hot months, ending with the first cold days of autumn. The epidemic begins in Buffalo about the 1st of July—fully two weeks later than in New York—and disappears about the middle of October. The youngest children are first affected, and if the atmospheric and other condi-

tions are favorable those of a more advanced age are attacked; the disease in these latter cases being more of a dysenteric than choleric form character. The maximum mortality of infants from diarrhœal diseases is reached in August. The maximum from dysentery is attained a month later, in September. It is, indeed, a remarkable fact that in Buffalo dysentery makes its appearance and passes away about one month after the choleric form diarrhœa of children. In the following table is given the mortality from diarrhœal diseases by months for the six years, 1881 to 1886 inclusive, with the percentage of deaths belonging to each month:

Months.	1881.	1882.	1883.	1884.	1885.	1886.	Total.	Per cent. of all.
January.....	0	1	4	5	0	6	16	$\frac{3}{5}$
February.....	0	3	2	3	3	2	13	$\frac{1}{2}$
March.....	0	4	7	4	4	1	20	$\frac{1}{5}$
April.....	0	2	0	0	2	0	4	$\frac{1}{6}$
May.....	5	6	1	5	9	5	31	$\frac{1}{5}$
June.....	9	9	9	16	5	7	55	2
July.....	110	51	68	58	112	149	548	21
August.....	121	171	169	193	142	123	919	35
September....	151	130	73	135	131	108	728	27
October.....	93	26	35	64	26	15	259	$9\frac{4}{5}$
November.....	9	1	9	8	3	5	35	$1\frac{1}{2}$
December....	2	0	2	5	6	4	19	$\frac{1}{5}$
Total.....	500	404	373	491	434	425	2,633	

The above table shows that these diseases belong almost exclusively to the third quarter of the year. They make their appearance about the first of June, but are not of a severe type until July, when the severity and frequency of the attacks rapidly increase until the maximum mortality is reached during the first few days of August.

1. *Temperature*.—Excessive heat is a prominent cause of infantile diarrhœa. Beginning in May, the curve of mortality from cholera infantum corresponds almost exactly with curve of mean temperature. Furthermore, it has been observed that the mortality curve of the summer diarrhœa of infants consists of recurring waves corresponding with the hot waves which pass over our country in the summer months. This has been demonstrated by the researches of Dr. S. Busey of Washington, in

connection with the late chief signal officer, Gen. Myer. This fact has been observed in Buffalo, as shown in a paper read before the Buffalo Medical Association in 1885. But it is evidently not the high temperature alone which causes the increased mortality from diarrhoeal diseases in summer. If this were the case we would find that the mortality would increase as we travel toward the equator, and that the mortality would be nearly as great in the country as in the city. New Orleans has a lower infant mortality in summer than Philadelphia, Chicago or Boston. In France the infant mortality is often higher in winter than in summer. Milne Edwards has made numerous experiments showing that cold is more injurious than heat to the health of young animals. August has been uniformly the hottest month in Buffalo, but in 1881 the greatest mortality from diarrhoeal diseases occurred in September, and in 1886 in July. Sudden changes of temperature are more important in the production of diarrhoeal diseases than a uniform high temperature, as the investigations of Dr. Busey have shown.

This writer has made a careful study of the subject in Washington, and has arrived at the following conclusions:

(1) The month of July is the hottest and sickliest month of the year, most conducive to bowel affections and most fatal to children under five years of age.

(2) The epidemics of the bowel affections of children incident to the summer season have their beginning nearly simultaneously with the first exacerbation of heat which usually occurs in the latter half of June; the maximum daily mortalities frequently corresponding with the maximum temperatures which occur in periods of three or more days at longer or shorter intervals during the summer months.

(3) With the usual lowering of temperature and the absence of excessive heat periods which occur after August, the daily mortality declines.

(4) The detrimental influence of summer temperature is intensified by sudden and acute elevations and falls.

(5) Children under one year of age are most numerous and seriously affected by the temperature influence.

2. *Humidity*.—Paul Bert has shown that more carbon dioxide is eliminated in moist air than in dry; consequently there is greater activity of tissue changes in moist than in dry weather. Furthermore moist air is a better carrier of zymotic poisons than dry. The dry Harmattan wind which blows from the interior of Africa puts an end to all zymotic diseases, even small pox.

Now, although we have the highest mortality from diarrhoeal diseases in the month when the average relative humidity is lowest, at the same time the absolute humidity and the hygrometric fluctuation is greatest. In hot weather children as well as adults are usually attacked with bowel complaints at night when the relative humidity is high. It is a common observation that cholera infantum is most fatal on hot, moist days. The moisture of the air diminishes the radiation of heat by evaporation, and at the same time increases the production of heat in the body, as is shown by the increased elimination of carbonic acid. The facilities for a careful study of the relations of humidity to disease are very imperfect. But it is quite probable that excessive moisture in the air prevents the rapid diffusion of emanations from the soil, which in hot weather in the city are of a dangerous character. It has been observed in New York and Baltimore that cholera infantum was extremely common and fatal among the children occupying basements, and it has been proposed to enact laws prohibiting landlords from renting basements for dwelling purposes.

3. *Rainfall*.—Rain is a great purifier of the air and soil. The great epidemics of the middle ages almost uniformly followed droughts. The highest death-rate in England during the past twenty-five years occurred in 1864, the year in which the rainfall was lowest. The highest mortality from diarrhoeal diseases in Buffalo occurred in 1881, the year in which there was a drought. During six weeks in August and September less than a quarter of an inch of rain fell, the atmosphere became hazy, vegetation was withered and dry, the soil was parched to a depth of five feet, the wells were dried, and in the thickly-

settled unsewered districts a disagreeable odor was everywhere observed. The infant mortality from diarrhœal diseases increased with the drought; in June there were nine deaths, July 110, August 121, September 151, October 93. Moreover, as the drought increased, the bowel affections assumed more of a dysenteric character. A fact particularly noticeable was that it was the children of more than one year of age who were chiefly affected by the drought. The mortality from diarrhœal diseases among those over one year of age was fifty per cent. higher than in any other year, whereas the mortality of those under one year of age was not increased. We may conclude then:

(1) That a drought in hot weather will increase the mortality from diarrhœal diseases.

(2) That the increased mortality is found chiefly among those over one year of age.

(3) That the diarrhœal disease occurring during a drought is liable to be of a dysenteric character.

(4) That the increased mortality is most marked in localities where sewerage is defective and the water supply derived from wells, as is shown by the fact that dysentery was most prevalent in the unimproved sections of the city.

4. *Velocity of wind.*—The movement of the air currents is more closely related to the prevalence of diarrhœal affections than is usually supposed. Running water will purify itself; in like manner the air is purified by diffusing and oxidising the injurious substances held in suspension. In Buffalo the maximum mortality from diarrhœal diseases occurs in the month when the movement of the winds is least. The National Board of Health discovered that this was true of twenty-seven cities investigated by them in regard to the prevalence of cholera infantum, San Francisco being the only exception. An extremely varying velocity of wind in hot weather will increase diarrhœal affections. In San Francisco the velocity is uniformly high, and the death-rate from infantile diarrhœal diseases is but 5 in 10,000; in New Orleans the velocity is uniformly low, and the death-rate is but 7 in 10,000. But in Buffalo, Boston,

Brooklyn and Chicago the velocity of the wind is extremely variable, and we find a mortality from diarrhœal affections amounting to 23, 24, 25 and 34 in 10,000 respectively.

The National Board of Health has reached the following conclusions regarding the relation of the velocity of the wind to diarrhœal affections :

(1) That the greatest mortality from diarrhœal diseases occurs in the month when the movement of the wind is least.

(2) The nearer the monthly movement of the wind approaches uniformity, the less the mortality from summer diarrhœa.

5. *Ozone*.—In Michigan the health authorities have studied the relation of atmospheric ozone to various diseases, and some very interesting phenomena have been observed, viz.: that maximum of acute respiratory diseases occurs in months when there is the maximum of atmospheric ozone, and that the maximum of acute intestinal diseases occurs when there is least atmospheric ozone. It has been recently demonstrated that the amount of atmospheric ozone is an index of the purity of the air. It is abundant at sea and in the mountains; it is wanting in cities during hot months and wherever there is abundant decomposing matter. When we discover, therefore, that there is most diarrhœal disease when there is least atmospheric ozone, the real meaning is that the air is most impure.

To sum up the relation of meteorological conditions to the prevalence of infantile diarrhœa we will state—

(1) That when there is more than the average of diarrhœal diseases the average daily range of temperature, the average temperature and the absolute humidity of the atmosphere are *greater* than the average for the year, and vice versa.

(2) That when there is more than the average of diarrhœal diseases, the relative humidity of the air, the rainfall, the average velocity of the wind, and the amount of ozone are less than the average for the year, and vice versa.

How does hot weather induce diarrhœa in children? The answer to this question hinges largely on the fact that the per-

spiratory functions of the infant are very defective or entirely wanting. Tardieu, Becher and Brown-Sequard have made experiments showing that the temperature of the adult body rises one degree for every twenty degrees sudden rise in the temperature of the surrounding atmosphere. In children the effect of atmospheric heat must be far greater. As perspiration is defective, nature attempts to maintain the normal heat by copious watery discharges from the bowels, a phenomenon attended by reduction of the temperature of the blood, and sometimes called sudoral diarrhœa. The digestive functions, moreover, are interfered with by the fever produced by heat, as it is a well-known fact that all fever patients are dyspeptic. But the principal action of the atmospheric heat is in the promotion of the decomposition of organic matter—filth—thus poisoning the air which the children are obliged to breathe.

IV. SANITARY CAUSES.

Summer diarrhœa is classified by sanitarians as a filth disease. It is common and fatal in cities, but rare in the rural districts. It is most prevalent in filthy localities, where the soil is contaminated and the sewerage and drainage are imperfect. In Buffalo it is most fatal in the thickly settled portion of the Fifth Ward, where there is a shallow clay soil poorly drained. There is least of this affection in the Ninth Ward, which has a sandy soil, well drained and occupied by a wealthier class of people. Many of the streets in the Fifth Ward occupied by Poles are without sewers, pavements or public water, the houses are overcrowded, the occupants filthy, garbage collects in the yards and is often thrown into the street. Many of the families occupy but one or two rooms. Soiled diapers are dried by the fire where the family diet is prepared. The children are seldom bathed, the adults never. When a child becomes ill a physician is seldom called until a death certificate is needed. It is not surprising then that the mortality from diarrhœal affections in these localities is nearly 100 per cent. above the average for the entire city.

Just how filth produces diarrhœa is not well known, for the same factors seem to vary in their effects upon different individuals. When the explorers Stanley and Dr. Livingstone were traveling together in Africa it was observed that the fetid miasms from swamps and marshes would cause fever in Stanley and dysentery in Dr. Livingstone.

Many hypotheses have been offered to explain how the emanations from decomposing matter may cause diarrhœal disease, but as yet nothing positive have been demonstrated. We will mention—

(1) *The Chemical Hypothesis*.—Dr. D. F. Lincoln maintains that the sulphureted hydrogen which is always evolved during process of decomposition of filth is converted into sulphuric acid gas in the air, and unites with sodium and ammonia bases to form purgative salts, sulphates of soda and ammonia. The continued inhalation of these gases and salts, he claims, will produce diarrhœa. In many persons the inhalation of sulphureted hydrogen will produce digestive disturbances, malaise and diarrhœa.

(2) *The Zymotic Hypothesis*.—While the gaseous constituents of foul air may have some influence in the production of diarrhœa, there are undoubtedly other substances of far greater importance. The greatest number of living germs is found in the air of filthy localities. The zymoses are supposed by the majority of pathologists to be living ferments. Burkart in 1873 investigated a form of diarrhœa which he denominated intestinal mycosis. This affection was supposed to be caused by taking diseased meat into the alimentary canal. A fungus was discovered in the meat and one which was identical with it growing in the intestines, even penetrating the lining epithelial cells. Walder in 1878, Bollenger in 1881, and Klein in 1885 studied the diarrhœal diseases of infants, and found that numerous micro-organisms, micrococci, vibriones and bacilli were always present in the intestines in these affections, but as yet no specific germ has been demonstrated.

(3) *The Ptomaine Hypothesis*.—Ptomaines, the alkaloidal

substance formed by putrefaction, are now attracting great interest in their relation to disease. Le Bon sent a communication to the French Academy of Medicine giving the results of his investigation of the cause of cholera and choleric form diarrhoea in India. The sacred ponds in India are often pools of stagnant water where the pious devotees of Brahma make their ablutions. Le Bon observed that Asiatic cholera and diarrhoea prevailed in the vicinity of one of these ponds. A chemical examination of the air and water revealed, besides the usual micro-organisms and gases, a ptomaine which he believed to be the cause of the diarrhoeal affection. "When air containing this ptomaine was inhaled for a long period the subject would be affected with true cholera, often of a fatal character, but when inhaled for a short period only, a choleric form diarrhoea was produced." In other words the character of the disease produced depended upon the dose of ptomaines taken into the system.

V. DIETETIC CAUSES.

Dujardin-Beaumetz has said that "the new-born infant is a digestive tube served by organs, and these organs are fitted to assimilate but one kind of food—the mother's milk." When food that cannot be digested is taken into the alimentary canal it undergoes putrefactive changes, and poisonous and irritating substances are formed, which induce inflammatory changes and diarrhoea. Probably the greatest discovery in physiology which has been made in this century is that of Armand Gautier, who has demonstrated beyond peradventure that the cells of animals as well as plants secrete alkaloids, substances which he has called *leucomaines*. These alkaloids are almost identical with those formed in plants; some act like strychnine, others like muscarine. Indeed Brieger has succeeded in transforming neurine, a harmless animal substance, into muscarine, a very poisonous alkaloid, by leaving it exposed in an aqueous solution to the air. A plant, when the atmospheric conditions and the character of the soil are not adapted to its growth, will form abnormal alkaloids, become diseased and die. It is quite probable that

the cells of animals will act in the same manner, forming abnormal alkaloids and producing an auto intoxication when the food and surrounding atmosphere are unsuitable, especially in the case of infants, whose organisms have not yet acquired the power of resisting untoward influences. Ptomaines are always present in the intestines. Tanret has obtained them by placing alkaline salts in contact with peptones. Brieger has found them where meat has been digested by gastric juice. When the intestinal membranes are in a normal condition and when the food is properly digested, the alkaloids are not absorbed into the blood, or are not of a poisonous character. But when putrefaction instead of digestion takes place in the alimentary canal, abnormal alkaloids are formed which, when absorbed through the intestinal membranes, produce a toxæmic diarrhœa * It is, moreover, probable that the congested intestinal mucosa will absorb substances which would not be taken up by the healthy membrane, just as the mucous lining of the bladder, when inflamed, will absorb readily what could not possibly be taken up in health. May we not explain the convulsions of infants so commonly observed in hot weather, by the absorption into the blood of an excessive quantity of these leucomaines, which resemble strychnine in their action? And is it not quite probable that some of the forms of diarrhœa—the choleraic, for example—are simply manifestations of an effort of nature to eliminate the poisons from the system?

Even the mother's milk will at times produce diarrhœa in the infant. When the mother is in ill health, when she becomes pregnant, and sometimes when the catamenia re-appear, changes take place in the milk which render it unfit for food. In some of these cases colostrum cells are detected, which account for the purgative action; in other cases nothing can be discovered

*At the Seance of the Paris Academy of Medicine, May 17, 1887, Hayem presented a communication on the treatment of dyspepsia of infants and the green diarrhœa of children. Having observed that the arrival of a child affected with green diarrhœa was the signal of an epidemic of this affection among the children in the crèche, Hayem suspected that the disease was of a contagious character and ordered a thorough disinfection of the stools and soiled clothing. As a result the epidemic immediately began to disappear. In connection with Dr. Lesage he has demonstrated that the green color of the stools is produced by a special bacillus which secretes a green substance during its development in the intestine. Hayem finds lactic acid the best germicide for the destruction of this bacillus.

to explain the effects observed. If nursing women take an excess of nitrogenous food, diarrhœa will be produced in the infant, especially in hot weather. In these cases there is an excess of casein in the milk. This casein is in part converted into peptones in the stomach, and the peptone alkaloids may be formed in too great quantities to be properly disposed of without inducing diarrhœa. When children take an excess of nitrogenous food it cannot all be disposed of in the construction of tissues, and an attack of diarrhœa and vomiting, with febrile disturbance, is produced to destroy and eliminate the waste products. To use the words of Fothergill, "There is a grand cleaning up, accompanied by a bonfire." Overfeeding, then, may be given as one of the causes of diarrhœa, even though nothing but mother's milk is given.

When infants obtain their milk from wet nurses the mortality is nearly double that of children nursed by their mothers. One of the best things which can be said of the good Queen of England is that she nursed every one of her ten children at her own breast. In some countries wet-nursing is the "trade," as Monot calls it, of thousands of women. But few of the well-to-do women of Paris nurse their own children. The wet nurses come from the country about the metropolis. During twelve years, in the village of Montsauche, 3,950 women were confined, and 2,710—nearly 70 per cent.—became wet nurses, 1,260 bringing children to the country and 1,450 going to Paris. During this period the mortality of the children of Montsauche, under one year of age, was 33 per cent. During sixteen months, in 1870 and 1871, when Paris was besieged, the women could not procure their infant charges from the city, and the mortality immediately dropped to 17 per cent.—about one-half. This statement needs no comments to show the immense superiority of maternal lactation. In Scotland wet nurses are almost unknown, and the infant mortality is the lowest in Europe—11 per cent. Even in Ireland, that land of famine, filth and fights, the infant mortality is but 14 per cent., a fact argely due to the universality of maternal lactation. Nature

seems to adapt the milk of the mother to the wants of the child according to its age, the milk of another woman being liable to cause indigestion and diarrhœa.

In our country, as in Scotland, the wet-nurse trade is almost unknown. But we have a far more reprehensible substitute—the nursing bottle. When the foundlings of New York were sent to the alms-house, one that attained the age of seven months was looked upon as a curiosity. Of the bottle-fed infants in the “baby farms” near Paris, 71 per cent. die during the first year. In New York more than one-half of the dry-nursed infants, under six months of age at the beginning of the hot season, die of diarrhœa before the summer is passed, and in the “baby farms” the mortality is even greater.

In the Edward Street Infant Asylum, of Buffalo, the Sister Superior informed me that if a bottle-fed baby lives to be three months old, even in winter, they think they have done remarkably well in preserving it to such a mature age, and in the summer to bring a foundling there is only a step before taking it to the cemetery. Furthermore she stated that 75 per cent. of the foundlings taken there died whether they were wet nursed or “brought up on a bottle.” So great has been the mortality and so discouraging have been the results, that she now refuses, as far as possible, to take foundlings in the institution. Last year more than three-fourths of the babies had their mothers with them, and yet the mortality was over 40 per cent. In reply to my question as to the nature of the diseases of which they died, she said that some seemed to waste away, but in summer they have diarrhœa and inflammation of the bowels. Those that are not nursed by their mothers, she said, have “one cow’s milk from the country.” In view of these facts, we must grant that the great fame acquired by Mrs. Joe Gargery for having brought Pip up by hand, was exceedingly well deserved. In countries where dry-nursing is rare, the second summer of the child’s life is considered most dangerous to its health, a fallacy which has been brought to our country by many foreigners.

A large share of the mortality from diarrhœal affections must

be attributed to the use of unhealthy milk. In Holland, she asses are driven about the streets and milked before the houses where bottle-fed infants are found. It is said that the mortality among children thus nourished is exceedingly low. Competent authorities state that next to the milk of the mother, that of the ass is the best adapted to the infantile digestive organs. But asses' milk is not obtainable here, and even in Paris it brings \$1.50 per quart. We are accordingly obliged in cities to content ourselves with milk which is supposed to have been derived from the cow. It is absolutely impossible to obtain fresh milk, and we are extremely fortunate if we can procure that which has not undergone partial decomposition.

Cows' milk will produce diarrhoea in children under the following circumstances :

(1) Where the milk contains colostrum. This substance is normally present in milk for a number of days after parturition ; it is also secreted when the udder is inflamed, and when the cow is in poor health.

(2) When the diet of the cow is improper. It is a well-known fact that poisonous substances taken in with the food will contaminate the milk. A large number of children in Rome, fed on goats' milk, were poisoned, the symptoms being vomiting and diarrhoea. It was found that the food of the goats contained colchicum, and the alkaloid of this plant was detected in the milk. An enormous quantity of refuse from starch and glucose factories, and from breweries and distilleries, is fed to the cows in and near cities. A thorough chemical examination of these waste products has never yet been made. There are many organic chemical compounds which have not yet been isolated in the laboratory, and it may be some of these which pass into the milk and cause the dyspepsia and diarrhoea of infants. It is a well-known fact that the milk of women and grass-fed cows is alkaline, while that of stall-fed cows, when starch refuse is used, is acid, and ferments rapidly. Fermented milk will almost invariably cause gastro-intestinal disturbances in infants.

(3) The milk may become contaminated after it has left the

cow with substances which will produce diarrhœa. Milk will absorb gases and sustain the life of micro-organisms. Lister considers it the best culture fluid in existence. Nature never intended that milk should be splashed in wagons about our streets in hot weather, poured from can to pail, from pail to pitcher, and fed to the baby perhaps 24 hours after it has left its native fountain. Such milk is of necessity in a state of decomposition, and decomposition means the formation of chemical substances which are in many cases poisonous, a fact which has been demonstrated by Dr. Vaughan of Mich., who has succeeded in isolating tyrotoxicon from samples of poisonous milk and cheese.

Much of the milk is now transported in air-tight bottles and people erroneously believe that fermentation is thus arrested. This is not the case, however, if the milk has not been boiled before being placed in the cans. If the milk is placed in the cans before it is cooled, and the morning milk is seldom cooled, fermentation goes on in the can and poisons are formed. Selmi has shown that the ptomaines formed when oxygen is deficient, as it must be in bottled milk, are far more poisonous than the ptomaines formed when oxygen is abundant.

Lastly, the ingestion of food not adapted to the age of the child will cause diarrhœa. It is not until the child has cut its first teeth that the glycogenic ferments are found in the salivary and pancreatic secretions, and until these ferments are formed, starches cannot be digested, but undergo decomposition, producing what Dujardin-Beaumetz calls putrid dyspepsia, an affection always attended by diarrhœa. If carbohydrate food is given at all before the first dentition, it should be in the form of maltose or grape sugar.

Moreover, the gastric juice in early life is deficient in pepsin. For this reason nitrogenous food, other than milk, should not be given in large quantities.

Fruit in cities is a dangerous article of diet for children. It is picked when green to avoid early decay, and often lies in markets and groceries surrounded by decaying vegetables, and

is sometimes liable to contamination from sewers, as is the case in our Elk Street Market. In the country enormous quantities of fruit are eaten by the children, and yet it seldom does harm unless it is unripe or matured too early on account of disease. But stale fruit contains poisons which will almost uniformly produce diarrhœa.

PREVENTIVE MEASURES.

From a review of the above conditions which predispose to diarrhœal diseases in children, we can easily deduce methods for their prevention. As the liability to these diseases varies inversely with the age, especial care must be exercised in the management of early infancy. And it will also be observed that male children will require more careful attention than female. By increasing the comforts and intelligence of the working classes, by removing their vices, we will greatly reduce their infant mortality.

Foundlings and illegitimate children should not be kept in asylums or alms-houses in the city, but should be sent to some establishment in the country, like the Thomas Wilson Sanitarium for children of Baltimore, where the best care and suitable food can be provided.

In hot weather the children should be kept out of the heat, and sudden chills should be avoided. Damp night air is especially to be feared. The bath should be given during the heat of the day, and not in the morning or evening. A flannel bandage should be worn over the abdomen to prevent sudden chills. All filth and dirt about the house or premises, such as foul garbage barrels, stinking privy vaults, or foul sewer receivers, should be looked upon as poisons liable to produce diarrhœa and death.

The municipal authorities should see that good water, adequate drainage and sewerage, and clean streets are provided in all sections of cities, especially in summer. Water should be given to the baby frequently during the hot season. Mothers should, as far as possible, nurse their own children during the

first nine or twelve months of life. Children should never be weaned just before or during the hot season ; that is, not later than May or before October.

When cows' milk is used it should be boiled and cooled before using. In this way not only are micro-organisms and poisons largely destroyed and fermentation arrested, but the milk is rendered more digestible. The milk should, if possible, in summer be boiled and bottled at the dairy. A careful surveillance of the milk supply should be exercised by the health authorities in all cities, as the evil too often exists in the food supply and condition of the cows.

During the first six months of life the diet should be milk, and milk alone, then a small amount of starchy food may be added, while meat should not be given before the child is three years of age. At this age also, fruit may be added to the diet, but uncooked fruit should be avoided in cities during the hot season.

Lastly, when cases of cholera infantum or green diarrhœa make their appearance in any locality, the physician should insist upon the careful disinfection of the alvine discharges and soiled clothing with lactic acid or strong solutions (1 per cent.) of corrosive sublimate.

